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TEM studies of W/C_{60} mixture prepared in a ball-mill.

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Many of tungsten-based materials are known for their prominent mechanical, thermal end electronic properties. At the present time new tungsten materials are intensely developed and fundamental mechanisms determining most interesting properties of tungsten compounds are actively studied.

In our work the mixture of tungsten nanoparticles powder and fullerene was treated in a ball-mill. The obtained mixture is supposed to be used for the preparation of mechanically tough material by subsequent baking. Tungsten nanoparticles in the precursor powder had size about tens of nm and mostly were faceted. The sample after the treatment was investigated in TEM (JEM2010 with 200kV acceleration voltage) using also EDS, EELS and EFTEM techniques.

Our studies have shown that the sample contains mainly nanoparticles of tungsten, tungsten carbide and minor amount of tungsten oxides nanoparticles (this was established by the crystal lattice analysis in high resolution images and by the EFTEM analysis of nanoparticles) (fig. 1, fig. 2). The size of the particles was approximately the same as in the precursor powder (sometimes smaller particles having size of some nanometers were observed) but almost all of the particles had irregular (non-faceted) shape. Apart of this we observed nanosized fragments of fullerene fcc-lattice (fig. 1). The EEL spectra taken from the carbon surrounding the tungsten nanoparticles also indicated the presence of fullerene. Some of the observed tungsten oxide particles were heterogeneous, and consisted of two different phases of tungsten oxide having different crystal lattices (fig. 2b).

Therefore, the treatment of the tungsten and fullerene in a ball-mill resulted in deformation of the initial nanoparticles and formation of tungsten carbide nanoparticles. The obtained sample represents itself a mixture of tungsten, tungsten carbide nanoparticles and nanosized fullerene lattice fragments with minor amount of tungsten oxides.

Observation of tungsten oxide nanoparticles with complex composition and the examination of their crystallographic features are of a big interest for both the fundamental studies and applications because of the important role of the tungsten oxides in gas sensor devices. It is well known from the scientific literature (see, for example, [1]), that there is a number of tungsten oxide phases with different crystal lattices and different physical properties, and their crystal structure is mostly determined by the content of the oxygen. The presence of two different phases of tungsten oxide in the same nanoparticle testifies complex kinetics of the tungsten nanoparticles oxidation, and can be studied further in order to find more details on this process.

1. M.R. Field, D.G. McCulloch, S.N.H. Lim, A. Anders, V.J. Keast and R.W. Burgess, J. Phys.: Condens. Matter 20 (2008), p. 175216.

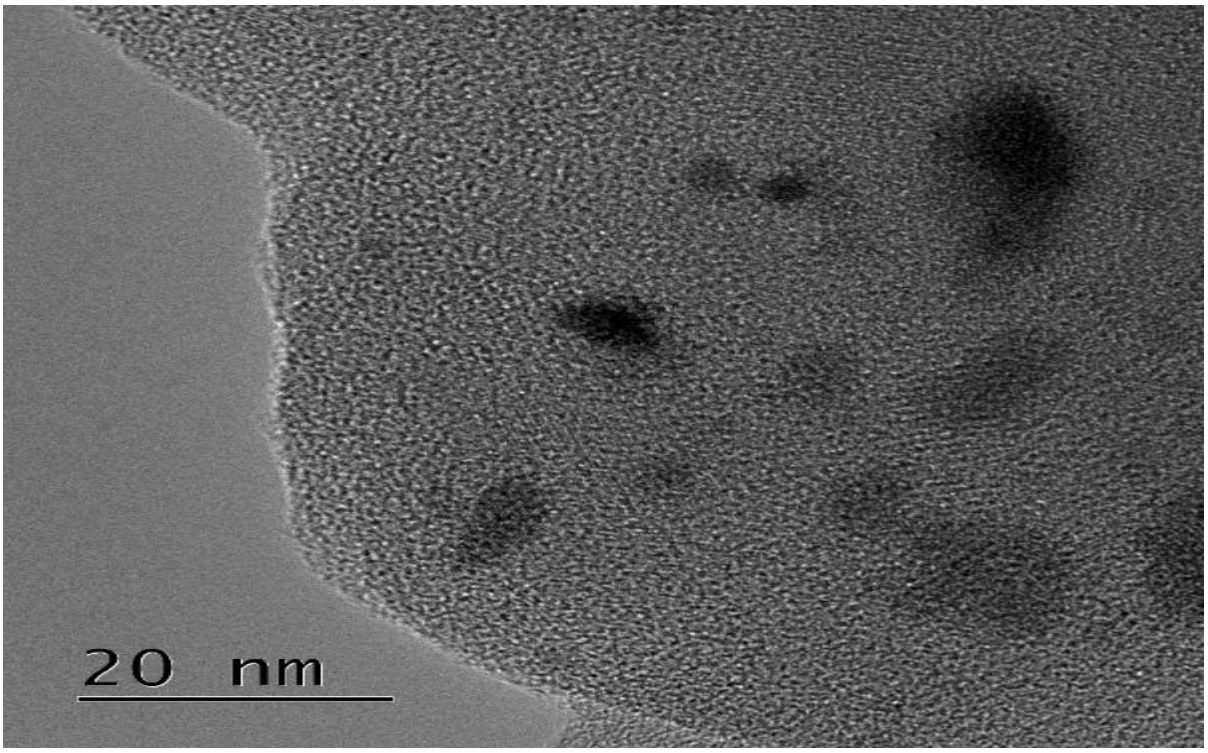

Figure 1. Nanoparticles of tungsten, tungsten oxide and carbide surrounded by nanofragments of fullerene fcc-lattice.

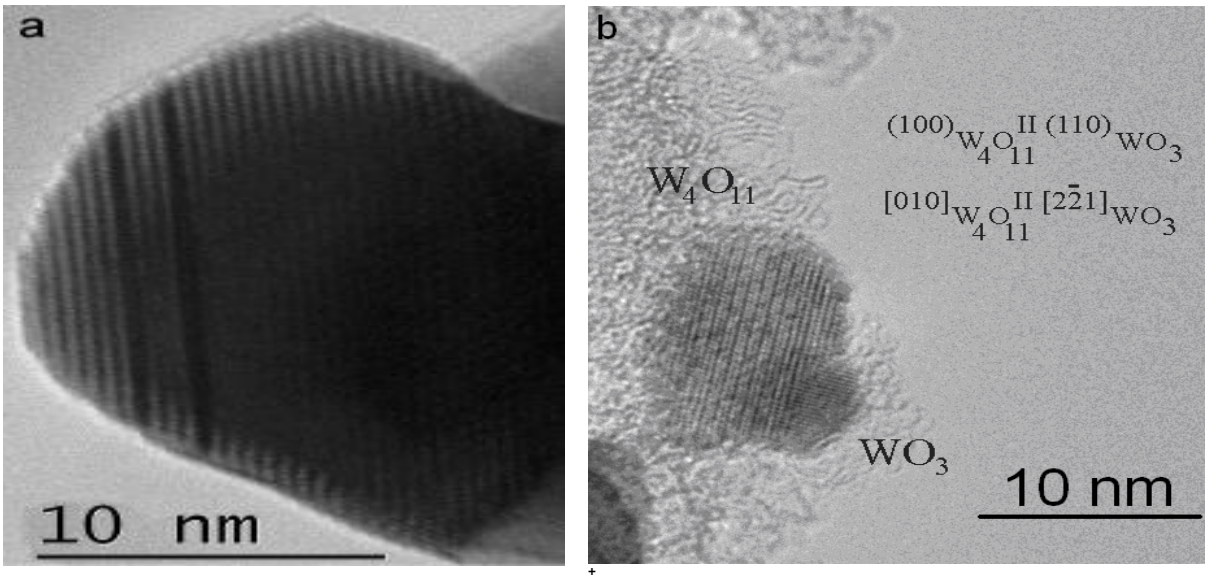

Figure 2. Nanoparticle of □-W_2C (a) and the nanoparticle containing WO_3 and W_4O_{11} (b).